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CHEMICAL COMPOUNDS AND METHODS FOR REMOVING DYE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to chemical compounds and methods for removing dye from polyester fibers, and more particularly to removing dye from panel fabric made from recycled poly(ethylene terephthalate) fibers.

2. Description of Related Art

Panel fabric, also known as vertical fabric, is used in furniture upholstery, wall systems and tackboards. Panel fabric is increasingly produced from synthetic materials such as polyester, most commonly PET (poly(ethylene terephthalate)). Panel fabric is replaced periodically and as a result, is often discarded in landfills. Many of the materials used in panel fabric are not biodegradable; thus disposal of it contributes to the environmental problems that arise from the over-use of landfills.

Manufacturers of panel fabrics and other materials incorporating PET are concerned about the effect of depletion of petroleum (used to make the polymers in the fabric) and the over-use of landfills on the environment. In an effort to reduce the amount of non-biodegradable waste that finds its way into landfills, some manufacturers use fiber made from recycled PET (often from recycled PET bottles, such as 2-liter soft drink bottles) in panel fabric. However, when the furniture incorporating

recycled or virgin panel fabric is discarded or refurbished, the fabric may nevertheless end up in a landfill. Reducing the vast amount of used panel fabric that is discarded annually as landfill waste by finding other uses for such materials is therefore advantageous.

However, merely finding other, lower valued uses for the PET in the panel fabric does not alone provide environmental sustainability. As the material is continually downgraded (*i.e.*, used in increasingly less valuable ways), demand for PET for the higher valued uses remains to be satisfied with either virgin PET, or PET that has been recycled from other uses. Accordingly, it is desirable to find a way to avoid downcycling the PET in panel fabric, *i.e.*, to reuse the PET in a way that is economically and environmentally of the same value as the panel fabric itself. Ideally, the PET in the panel fabric would be recycled into fiber that can be reused, *e.g.*, suitable for weaving into new panel fabric. In this way, the material is not only rendered recyclable, but recyclable in a sustainable fashion, decreasing the need for virgin PET or PET recycled from bottles, which can then be put to other uses.

Currently, when furniture incorporating panel fabric made from recycled PET is discarded or refurbished, any PET that may be recovered when garnetted into loose fibers is unsuitable for significant reuse in panel fabric and carpet manufacturing. The staple fiber is generally too short to be reused in the yarn spinning process at more than about 3%. If the fibers

could be melted, pelletized and extruded into full-length fiber, they could be recycled at about 100%. Unfortunately, the presence of dyes in the fibers makes them difficult to melt and extrude. The dye molecules char and burn at extrusion temperatures, forming a residue that blocks the extrusion spinnerets. As a result, a process capable of removing dye before extrusion is needed.

Existing processes may strip or decrease dye levels in polyester, but they do so by breaking the chromophore of the dye. Methods commonly used for color removal employ harsh chemicals like sodium bisulfite, which hydrolyze or oxidize the dye, leaving the decolorized dye in the fiber. This eliminates the color, but leaves the remainder of the dye molecule in the fiber. Thus, when the fiber is melted and extruded, the remaining molecule chars and burns, blocking the extrusion spinnerets.

J.R. Aspland, Textile Dyeing and Coloration (American Ass'n of Textile Chemists & Colorists 1997) describes the removal of dye from a polyester fiber at room temperature using methylene chloride. However, this solvent damages the polymer by swelling the PET fiber and solvating the dye. The damage caused is partial hydrolysis of the PET, which causes loss of strength and brittleness in the fibers. For at least this reason, this method is inappropriate for use in manufacturing new carpet or panel fabric. There is therefore a need in the art for a dye removal process that does not damage PET, but effectively removes dye from it.

SUMMARY OF THE INVENTION

The invention solves some or all of the above mentioned problems by providing methods and compositions for removing dye molecules from polyester, PET in particular. The invention allows the PET to be reused by pelletizing and extruding it into fiber suitable for panel fabric or other applications calling for virgin PET, without disrupting the extrusion process by dye molecule charring.

The invention addresses the problem of downcycling the PET in panel fabric by providing a way to use recycled PET that is economically and environmentally of the same value as the panel fabric itself. By using the method of the invention, the PET can be melted, extruded and reused as panel fabric. The invention is an improvement over existing processes because it completely removes the dye molecules from the PET, instead of breaking only the chromophore of the dye. Thus, when the method of the present invention is used, the PET may be melted and extruded, without remaining dye molecules burning or blocking the extrusion spinnerets. Furthermore, the method of the present invention does not damage the PET by swelling.

According to one embodiment of the invention, a method is provided for removing dye from polyester fiber or fabric by contacting the polyester with a dye removal composition containing an aqueous solution of at least one leveling agent; heating the mixture of polyester and dye

removal composition until it reaches an elevated temperature and pressure level higher than the equilibrium pressure of the dye removal composition at the elevated temperature; cooling the mixture; and removing the decolorized polyester from the mixture.

According to another embodiment of the invention, a composition for removing dye from polyester is provided. The composition includes an aqueous solution of about 0.5 wt% to about 8.0 wt% of at least one leveling agent.

In another embodiment, the invention relates to a device for removing dye from polyester according to the present invention. The device includes a sealable vessel and a dye removal composition. The dye removal composition includes an aqueous solution of about 0.5 wt% to about 8.0 wt% of at least one leveling agent.

The invention is also directed to a method for recycling panel fabric comprising polyester. The method involves removing from the fabric any structural elements, removing the dye from the fabric using a dye removal composition comprising an aqueous solution of at least one leveling agent, recovering the polyester fibers, melting the fibers, pelletizing the melted fiber and extruding the pellets into full-length fiber.

In a particular embodiment of the invention, the dye removal composition comprises at least one leveling agent selected from the group

consisting of anionic leveling agents, nonionic leveling agents and mixtures thereof.

In another particular embodiment of the invention, the dye removal composition further comprises at least one chemical selected from the group consisting of scouring agents, wetting agents and leveling carriers. Leveling agents may perform one or more of these functions in addition to their function as leveling agents.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

The invention provides for a method of removing dye molecules from polyester fiber, and is particularly useful with PET fiber. The polyester may be used in the process as woven fabric or, alternatively, garnetted into loose fibers. The polyester is contacted with a dye removal composition comprising an aqueous solution of at least one leveling agent. This may be conveniently done in a standard dyeing vessel commonly used for disperse dyeing of polyester, which is sealable and temperature controlled.

Effective leveling agents have good wetting, emulsifying and dispersing properties and will prevent redeposition. A leveling agent that promotes maximum coverage and color yield is also desirable. Leveling agents particularly suited for high temperature polyester dyeing will generally be suitable for the present invention. Effective leveling agents

can also inhibit cationic dye from staining and settling on the walls of stainless steel equipments.

The dye removal composition comprises an aqueous solution of at least one leveling agent. Suitable leveling agents include anionic leveling agents, nonionic leveling agents and mixtures thereof. The dye removal composition may further comprise leveling carriers, scouring agents and mixtures thereof. In a particular embodiment of the invention, the scouring agent or wetting agent is nonionic. In another embodiment of the invention, the leveling carrier comprises a nonionic leveling carrier.

More particularly, examples of suitable leveling agents include those that comprise alkyl polyglycol ether, isopropyl alcohol, n-butyl phthalimide or nonyl phenol ethoxylate. Examples of suitable leveling carriers include those containing alkyl phthalimide. Examples of suitable scouring agents include scouring agents containing polyoxyethene ether or propylene glycol ether. In a most preferred embodiment of the invention, the dye removal composition comprises isopropyl alcohol, n-butyl phthalimide, nonyl phenol ethoxylate, and propylene glycol ether.

Particular leveling agents that may be used for the present invention include AVOLAN IW LIQUID™ nonionic leveling agent and scouring agent (Bayer, Pittsburgh, PA), DIADAVIN UFN™ nonionic leveling wetting and scouring agent (Bayer, Pittsburgh, PA), LEVEGAL EAP-4™ leveling carrier (Bayer, Pittsburgh, PA), RAYCAPOL TDA-33 scouring

agent (Clariant, Chicago, IL), RAYCALEV D™ (leveling agent), CAROLID NOL leveling agent (Bayer, Pittsburgh, PA) and RICHLEV D leveling agent (Richchem, High Point, NC), BURCO SOUR LFE-810™ scouring agent (Burlington Chemical Co., Burlington, NC).

When mixed with water or aqueous solution, the leveling agents can be used in weight ratios ranging from (under certain conditions) about 0.5% to as high as about 8.0% of leveling agent : water. However, particularly desirable results are achieved when the leveling agent(s) is present in an amount ranging from about 2.0 wt% to about 8.0 wt% of the total solution of leveling agents. An approximately 4.0 wt% aqueous solution of leveling agent(s) has been found to be particularly suitable for most applications. More particularly, an approximately 4.0 wt% solution comprising propylene glycol ether, isopropyl alcohol, n-butyl phthalimide and nonyl phenol ethoxylate and water has been found to be suitable for most applications.

According to this invention, the polyester to be decolorized is separated from any structural elements and placed in a sealable vessel. The polyester may be woven fabric or loose fibers. Water and a dye removal composition comprising at least one leveling agent are added to a vessel at a temperature of about 20°C to about 25°C. Those with skill in the art will understand that any vessel made of a nonreactive material and sealable may be used in place of a standard dyeing vessel.

The mixture of the polyester and dye removal composition are heated for a period of about 120 minutes. Because the vessel is sealed, as the temperature increases, there is a corresponding rise in the pressure. Thus, the pressure is higher than the equilibrium pressure of the dye removal composition at the elevated temperature. When the pressure has reached about 28 psi to about 39 psi, more particularly about 33 psi, and the temperature has reached about 135°C to about 145°C, more particularly 140°C, the vessel is maintained at that pressure and temperature for about 30 minutes to about 60 minutes, more particularly about 45 minutes.

The vessel may be agitated during the period when the polyester is first contacted with the dye removal composition, when it is heated, during the holding period when the temperature and pressure are maintained, or any combination of these three. Agitation can be achieved, for example, by rolling the vessel or by continuously pumping the dye removal composition through the polyester.

The holding stage is typically followed by a cooling down period of about 20 minutes to about 40 minutes wherein the temperature is decreased to about 20°C to about 50°C, more particularly 30°C. The mixture should be cooled rapidly to prevent or limit reabsorption of the dye by the polyester.

The times and temperatures may vary somewhat depending upon the dyestuff and the leveling agent chosen, but will generally fall within the above ranges for most commonly encountered dyes.

The decolorized polyester is then removed from the mixture. Any residual dye removal composition should be removed from the polyester, in order to further limit the chance of reabsorption. This can often be achieved by rinsing thoroughly with water.

This cycle may be repeated as needed to remove additional dye from the polyester fiber or fabric. Those with skill in the art will recognize that more intense colors may require additional cycles to sufficiently decolorize the polyester. The method may be carried out as a batch, sequential batch semi-continuous or continuous process.

The invention may be used to recycle panel fabric made from polyester. The invention is also useful for recycling panel fabric made from polyester that has already been recycled, such as recycled PET. To recycle panel fabric, it should first be separated from any structural elements. The fabric can be, but is not required to be garnetted into loose fibers. In order to fully recycle the panel fabric so that it can be used again as panel fabric or some other product of similar economic and environmental value, any dye should be removed using a dye removal composition comprising an aqueous solution of at least one leveling agent. Once the dye has been removed, the polyester fibers can be recovered. The

fibers can be melted and pelletized before being extruded into full-length fiber. Panel fabric may be created by weaving the recycled fiber.

The invention can be more clearly understood by reference to the following examples, which are not intended to limit the scope of the invention in any way.

EXAMPLE 1

The process was carried out in an Ahiba Polymat dyeing machine in sealed vessels. Fifty (50) mL of water was added to an empty vessel. Four (4.0) mL of each of the following chemicals were also added to the vessel: CAROLID NOL™ leveling agent, BURCO SCOUR LFE-810™ scouring agent, and RICHLEV D™ leveling agent. Approximately 5.00 g of polyester was placed into the vessel. Fifty (50) mL of water was added to the vessel to cover the polyester. The vessel was sealed. The vessel was rolled to agitate the mixture. The temperature was raised from room temperature (about 22°C) to 50°C. The temperature was held at 50°C for 3.3 minutes. Next, the temperature was raised, over 40 minutes, to 70°C at a gradient of 0.5. The temperature was then raised to 140°C at a gradient of 1.5 over a period of 46.7 minutes. Finally, the temperature was reduced, over 30.0 minutes, to 50°C at a gradient of 0.5. The total running time was 116.7 minutes.

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The foregoing description is provided for describing various embodiments and structures relating to the invention. Various modifications, additions and deletions may be made to these embodiments and/or structures without departing from the scope and spirit of the invention.